

Claims

What is claimed is:

1. A method for the analysis of impurities in a main gas comprising:
 - (a) an ionization of impurity atoms and molecules in their collisions with particles of definite energy in an ionization chamber;
 - (b) measurement of an electric current between at least two electrodes at least one of which is an anode and one of which is a cathode positioned in said chamber, as a function of the voltage applied between said two electrodes;
 - (c) selection of a main gas pressure and of said ionization chamber geometry in such that a distance between any point in said chamber and the nearest chamber wall or one of said electrodes is of the order or less than a mean displacement of an electron before it loses a given portion of its kinetic energy;
 - (d) providing equipotential space at the region of said ionization chamber, where said ionizing collisions occur;
 - (e) determination of amount of electrons with characteristic energies, which are generated in the ionization of said atoms or molecules, from electric current dependence on the voltage applied between said electrodes; and
 - (f) identification of said impurities in said main gas from parameters of said electrons.
2. The method of claim 1 wherein said main gas is a noble gas.
3. The method of claim 2 wherein said main gas is helium.
4. The method of claim 1 wherein said main gas pressure may vary from 10 to 10^5 Pa and above with appropriate change in said ionization chamber geometry.
5. The method of claim 1 wherein a voltage applied between two said electrodes is varied from 0 to the ionization threshold of said main gas, and the amount of said electrons with the characteristic energies is determined from the second derivative of the electric current dependence on the voltage applied.
6. The method of claim 1 wherein said equipotential space is created in said ionization chamber region by using a pulsed power source to produce an afterglow plasma in the ionization chamber; said impurity atoms or molecules are ionized in collisions with metastable atoms or molecules of said main gas, generated under the effect of said pulsed power source; said current is measured with a time delay following the power source effect; and the concentration and temperature of the charged particles in the afterglow plasma at the moment of measurement are provided so that the Debye length is less than the dimensions of said ionization chamber.

7. The method of claim 6 wherein a pulsed glow discharge ignited between said electrodes is used as a said pulsed power source.
8. The method of claim 6 wherein pulsed laser radiation as a said pulsed power source is used to create plasma in the gap between said electrodes.
9. The method of claim 6 wherein said impurity atoms or molecules are ionized when said afterglow plasma is irradiated by photons of a given energy from an external source.
10. The method of claim 9 wherein said impurity atoms or molecules are ionized by irradiation by photons resonant to the atoms or molecules of said main gas.
11. The method of claim 1 wherein said electrodes have a planar shape and are parallel each other.
12. The method of claim 6 wherein said ionization chamber is used with N insulated cathodes positioned inside; an individual voltage with respect to one or several anodes is applied to each cathode; the current across each of the N cathodes is measured; the amount of electrons with the characteristic energy values, which are generated in the ionization of the impurity atoms or molecules, is found from combined data on the currents measured.
13. The method of claim 1 wherein a conducting grid is placed between said electrodes, which is electrically connected to an anode to create an equipotential space between them; the impurity atoms or molecules are ionized by irradiating the space between said grid and said anode by neutral particles of definite energy from an external source.
14. The method of claim 13 wherein said electrodes and said grid have planar shapes and are arranged in parallel.
15. The method of claim 13 wherein the impurity atoms or molecules are ionized by photons resonant to the atoms of said main gas.
16. The method of claim 13 wherein an electric charge passed across a cathode is controlled; when said charge exceeds the prescribed value, said external source is turned off and an electric field is applied until charged particles are removed from said inter-electrode gap; then said external source is turned on and the current is measured again.
17. The method of claim 13 wherein N insulated cathodes are positioned in said ionization chamber; an individual voltage relative to corresponding grids and one or several anodes is applied to each cathode; the individual current across each of the N cathodes is measured; combined measured current values are used to find the amount of electrons with the characteristic energies, produced in the ionization of said impurity atoms or molecules.
18. The method of claim 1 further comprising a process wherein the impurities to be analyzed are provided by a target sample material atomization using with an additional power source;

the impurities formed are mixed with said main gas and are delivered into said ionization chamber.

19. The method of claim 18 wherein said target sample is used as a cathode atomized by a preliminary plasma discharge ignited by said additional power source.

20. The method of claim 18 wherein the impurity molecules are pre-dissociated into atoms in an additional plasma discharge and the atomic composition of said impurities is analyzed.

21. An ionization detector for the analysis of the impurities composition in a main gas, comprising:

- (a) an ionization chamber filled with said main gas and impurities mixture and, at least, two electrodes at least one being an anode and one being a cathode inside of said chamber, wherein said main gas pressure and the ionization chamber geometry being chosen in such that a distance from any point inside of said ionization chamber to nearest chamber wall or one of said electrodes is less than a mean displacement of electrons before they lose the chosen portion of their kinetic energy;
- (b) an equipotential space provided at the region of said ionization chamber where said impurities ionization occurs;
- (c) a power source generating particles with definite energy to ionize said impurity atoms or molecules;
- (d) a measuring circuit to detect electric current as a function of the voltage applied to said electrodes wherein said measuring system is capable of determining the amount of electrons with characteristic energies produced during the ionization of said impurities.

22. The ionization detector of claim 21 wherein a noble gas is used as said main gas.

23. The ionization detector of claim 22 wherein helium is used as said main gas.

24. The ionization detector of claim 21, wherein said main gas pressure varies from 10 to 10^5 Pa and more.

25. The ionization detector of claim 21 wherein the voltage applied between two said electrodes is varied in the range from 0 to the ionization threshold of said main gas, and said measuring system is designed to find second derivative of the current dependence on the voltage applied to determine the amount of electrons with the characteristic energy values.

26. The ionization detector of claim 21 wherein said power source is a pulsed generator to create an afterglow plasma in said ionization chamber; the measuring system is designed to register the electric current with a time delay after the plasma generator pulse; said generator is capable of producing sufficient concentration of metastable atoms of the main gas to

register the electrons with the characteristic energies, formed in the impurities ionization by said metastable atoms, said generator is also capable of producing such concentration and temperature of charged particles in the afterglow plasma that the Debye length is less than the dimensions of the ionization chamber at the moment of the current measurement.

27. The ionization detector of claim 26 wherein said power source ignites a pulsed glow discharge between two said electrodes.

28. The ionization detector of claim 26 wherein said power source is a pulsed laser creating plasma between two said electrodes.

29. The ionization detector of claim 26 wherein an additional external source of photons of definite energy is installed to ionize the impurity atoms or molecules in the afterglow plasma.

30. The ionization detector of claim 29 wherein said additional external source generates photons resonant with the atoms or molecules of said main gas.

31. The ionization detector of claim 21 wherein said electrodes are of plane-parallel shape.

32. The ionization detector of claim 21 wherein said ionization chamber comprises N insulated electrodes; an individual voltage is applied to each of said electrodes relative to one or several connected anodes; said measuring system is capable of measuring the individual electric current across each of N said cathodes as a function of the applied voltage.

33. The ionization chamber of claim 21 wherein a conducting grid is positioned between two said electrodes and is electrically connected with said anode to create an equipotential space between them; an external source of neutral particles of a definite energy is installed in such a way that the impurity atoms or molecules are ionized due to the irradiation of the space between said grid and said anode.

34. The ionization detector of claim 33 wherein said electrodes and said grid are plane-parallel to each other.

35. The ionization detector of claim 33 wherein said external source generates photons resonant with the atoms or molecules of said main gas.

36. The ionization detector of claims 33 wherein said measuring system is designed capable of controlling the current across said cathode; when this current exceeds a prescribed value, said measuring system turns off said external source, applies an electric field until the charged particles are removed from said inter-electrode gap, then turns on said external source again and continues to measure the current.

37. The ionization detector of claim 33 wherein said ionization chamber contains N insulated cathodes; individual voltage is applied to each of said cathode relative to corresponding grid

and one or several anodes; said measuring system is capable to measure the current across each of said N cathodes individually.

38. The ionization detector of claim 21 wherein an additional power source is used to atomize a sample target material as an impurity into said main gas and there are means for supplying said mixture to said ionization chamber for the composition analysis.

39. The ionization detector of claim 38 wherein said sample target is installed as a cathode for atomization by a preliminary plasma glow discharge ignited by said additional power source.

40. The ionization detector of claim 21 wherein an additional plasma discharge source is used to produce pre-dissociation of sample molecules into atoms for the analysis of the elemental composition of the sample in said ionization chamber.

41. The ionization detector of claim 33 wherein said external radiation source further comprises:

- (a) a cylindrical window transparent to this radiation;
- (b) two electrodes covering the butt sides of said window;
- (c) a power source to ignite a glow discharge inside of said cylindrical window between said two electrodes;

said external radiation source contains argon and is mounted inside of said ionization chamber; said anode, cathode and grid for photoelectrons detection are formed as plane-parallel rings external to said cylindrical window and arranged coaxially with said cylindrical window in such a way that the radiation penetrates only the space between said anode and said grid.